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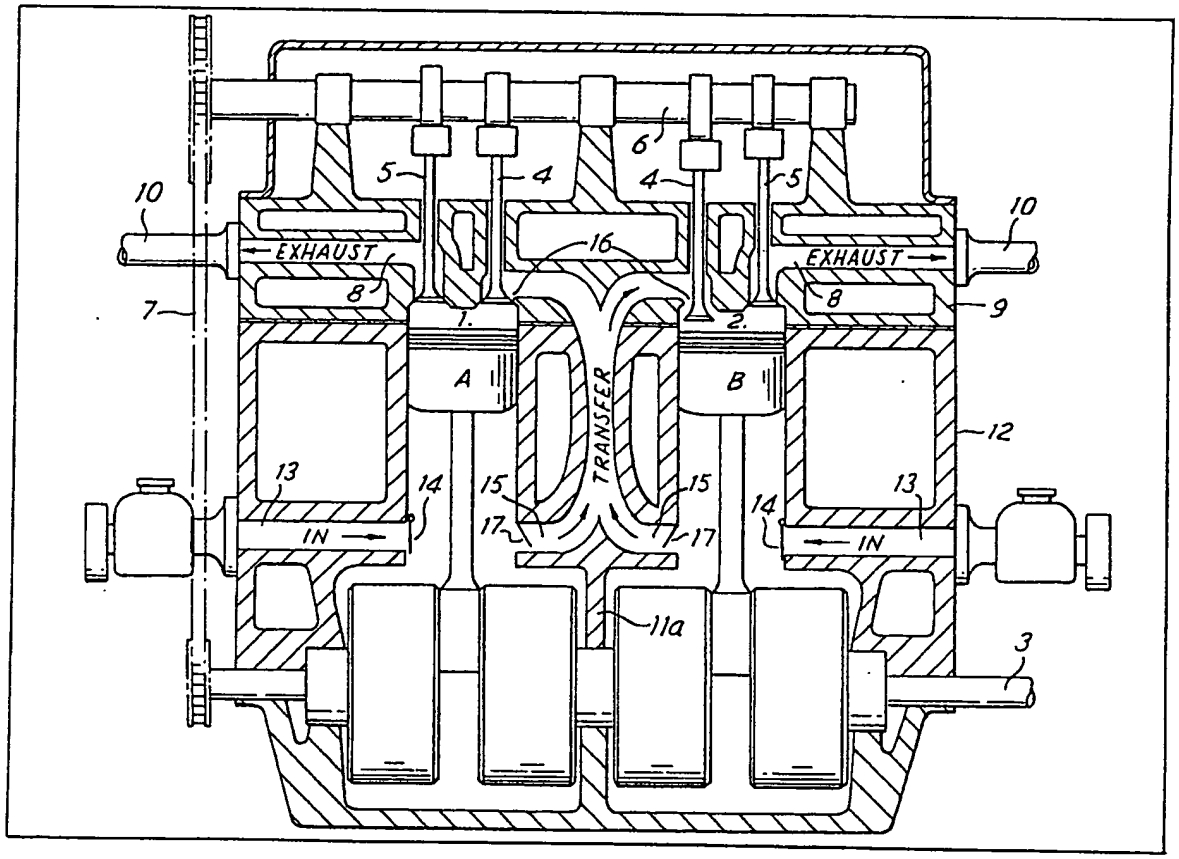
(54) Crankcase charged four-stroke I.C. engine

(57) In a four-stroke internal combustion engine the cylinders are arranged in pairs with pistons A and B reciprocating in phase and driving a common crankshaft 3. Valved transfer conduits 15 interconnecting each pair of cylinders. Fuel/air mixture is introduced via fuel inlets 13 alternately into the two cylinders on the low pressure side of the respective piston, which, on its downward (ignition) stroke, compresses the fuel/air mixture and feeds it under pressure to the adjacent cylinder, thus operating as a supercharger for the other cylinder. The operating cycle of the two cylinders is 180° out of phase so that as one follows the sequence of induction, compression, ignition, exhaustion the other operates according to the sequence of ignition, exhaustion, induction, compression.



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The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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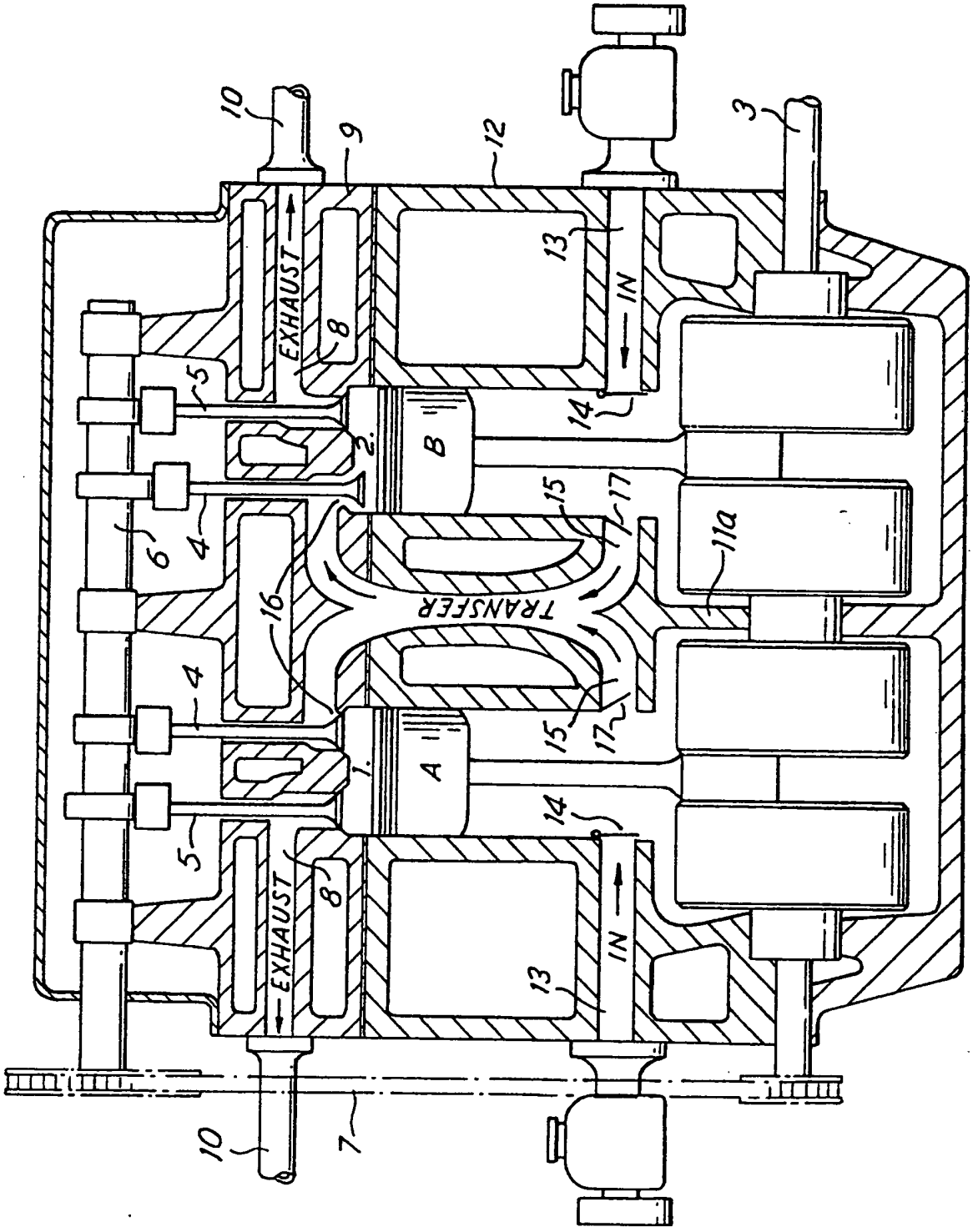
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SPECIFICATION

Internal combustion engine

This invention relates to internal combustion engines. More particularly this invention relates to four-stroke internal combustion engines provided with a supercharger for feeding a precompressed mixture of fuel and air to the cylinder, and concerns such an engine having a novel form of supercharger which permits a substantial increase in the output torque of the engine with a reduced level of exhaust emission.

In accordance with one aspect of this invention there is provided a four-stroke internal combustion engine, comprising one or more pairs of cylinders, a piston mounted for reciprocation in each of said cylinders, a crankshaft, or two separate shafts, rotatably mounted in a crankshaft casing and connected by connecting rods to said pistons, the crankpins on said shaft or shafts being axially aligned whereby the two pistons reciprocate in their respective cylinders in phase one with the other, one or more inlet passageways communicating with the crankcase for admission of a fuel/air mixture thereto, said passageway(s) being provided with a non-return valve, or in a position to be closed by the pistons on their downward stroke, an inlet port and an exhaust port communicating with each of said cylinder, a valve member associated with each of said inlet and exhaust ports and means for opening and closing said valves in timed sequence, and characterised by a transfer passageway or passageways communicating from the crankshaft casing to the inlet ports of said pair of cylinders for feeding thereto a compressed fuel/air mixture from said crankshaft casing during the downward stroke of the two pistons, the timing mechanism being operative to admit said compressed fuel/air mixture from the crankshaft casing into one of said two cylinders on the first downward stroke of the four-stroke cycle and into the other of said two cylinders on the second downward stroke, and said timing means being operative to open said exhaust valves so as to vent exhaust gases from said one cylinder during the second upward stroke of the said four-stroke cycle and from the said other cylinder during the first upward stroke, whereby each piston operates according to a four-stroke cycle of induction, compression, ignition (power) and exhaustion, but two strokes out of step one with the other. Therefore whilst the first piston performs its induction and compression strokes, the second performs its ignition (power) and exhaustion strokes, and *vice versa*. Moreover during each upward (compression or exhaustion) stroke, the two pistons will each induce a fuel/air mixture into the crankcase (i.e. a double charge of fuel and air), and during the downward (ignition/induction) stroke this double charge of fuel and air will be pumped into one of the two cylinders, which thus is supercharged with a double charge of precompressed fuel and air. Hence the increase in the torque output during the following ignition (power) stroke.

In accordance with a second aspect of this invention there is provided a method of operating a four-stroke internal combustion engine, said engine having one or more pairs of cylinders each having a piston mounted for reciprocation therein and each piston connected to a crankshaft rotatably mounted in a crankshaft casing, each piston in operation performing a four-stroke cycle of induction, compression, ignition (power) and exhaustion, wherein the two pistons of said pair are arranged to reciprocate in phase one with the other, the one performing its induction and compression strokes whilst the other performs its ignition (power) and exhaustion strokes and *vice versa*, and wherein during the compression stroke of the one piston and the exhaustion stroke of the other, an air/fuel mixture is inducted into the crankshaft casing by both said pistons, and during the ignition (power) stroke of the one piston and the induction stroke of the other, the said air/fuel mixture is precompressed in said crankshaft casing by said pistons and fed thereby under pressure into the cylinder associated with the piston, which at that time is performing its induction stroke.

The invention will be further described with reference to the accompanying drawing which diagrammatically illustrates a section through an engine constructed in accordance with this invention. Although this drawing illustrates an engine having only two cylinders, it will be obvious that the principle of the invention can be applied to any four-stroke internal combustion engine having an even number of cylinders. Before referring in detail to the drawing, it will be understood that this drawing only includes such features as are necessary to an understanding of the principle behind this invention. The drawing, therefore, does not show the many conventional features, e.g. spark plugs etc., which are necessary to the operation of the engine, but which do not form any part of the invention as such.

Referring now to the drawing, the engine of this invention comprises two cylinders 1, 2 or any number of pairs of cylinders, in which are mounted two pistons A, B for reciprocation therein. The two pistons A, B are connected by conventional connecting rods to either a common crankshaft 3, or to two separate crankshafts which rotate at the same speed. In either case respective crankpins are at the same angular position relative to the axis of the shaft so that the two pistons A, B reciprocate together.

In the upper part of each cylinder are inlet valves 4 and exhaust valves 5 operated in a sequence to be described by a camshaft 6 driven in timed relationship with the crankshaft 3 by a drive chain 7 shown in outline. The exhaust valves 5 communicate via exhaust passageways 8 in the cylinder head 9 with exhaust manifolds 10.

Communicating with the crankcase 11 in the lower part of the cylinder block 12 are fuel inlet passageways 13 for the admission of a fuel/air mixture into the crankcase. As shown, the inner ends of the two fuel inlet passageways 13 are

provided with non-return reed or flap valv s 14, although, in an alternative c nstruction, the fuel inlet ports can be so positioned that the ports into the crankcase ar covered and uncovered by the respectiv piston during the downward and upward strokes respectively.

Finally, and characteristically in accordance with this invention, transfer passageways 15 are provided in the cylinder block 12 communicating between the crankcase 11 and with each of the two inlet ports 16 into the cylinders 1, 2 and which are opened and closed in timed sequence by the inlet valves 4. In the configuration shown, the two transfer passageways 15 form a generally X-shaped configuration and provide communication between both the inlet ports 16 into the cylinders 1 and 2, and both sections of the crankcase 11. However, other configurations are possible. For example, where the crankshaft 3 is accommodated in an undivided crankcase, i.e. without the central dividing web 11*a*, a single Y-shaped transfer passageway 15 will suffice to provide communication between the crankcase and each of the two inlet ports 16. In yet another possibility, where a divided crankcase is used, as shown, the X-shaped transfer passageway can be replaced by two Y-shaped passageways each providing communication between a different one of the two sections of the crankcase and the two inlet ports 16 into the cylinders 1 and 2. In any event, the inlet end of the or each transfer passageway, i.e. the end or ends of the transfer passageway or passageways 15 communicating with the crankcase 11 are closed by non-return reed or flap valves 17.

Referring now to the operation of the engine shown in the drawing, in the position as shown piston A may be considered as having reached the end of the compression stroke in a conventional four-stroke engine cycle, with both the exhaust 5 and the inlet valves 4 closed. The cylinder 1 will contain a highly compressed fuel/air mixture ready for ignition by a sparking plug (not shown). Piston B may be regarded as having reached the end of the exhaust stroke of the conventional four-stroke cycle (the exhaust valve 5 in cylinder 2 just having closed), and about to commence the induction stroke (the inlet valve 4 into cylinder 2 just having opened).

During the immediately preceding stroke (both pistons having travelled together), i.e. the compression stroke of piston A and the exhaust stroke of piston B, a double charge of fuel/air mixture will have been drawn by the ascending pistons into the crankcase 11 via the fuel/air inlet ports 13.

Ignition of the compressed fuel/air mixture in cylinder 1 by the sparking plug (not shown) initiates the power stroke of piston A. During this power stroke of piston A, both pistons will travel downwardly together thus compressing the fuel/air mixture previously inducted into the crankcase, and pumping the compressed mixture via the transfer passageways 15 into cylinder 2 via the open inlet valve 4. Thus cylinder 2, during the induction stroke of piston B, will receive a double charge of precompressed fuel/air mixture from the crankcase 11.

In the course of the next upward stroke, which will be the exhaust stroke of piston A and the compression stroke of piston B, the exhaust valve 5 of cylinder 1 will open whilst the inlet valve 4 of cylinder 1 will remain closed. In the case of piston B, of course, both the inlet and exhaust valves will remain closed. Also during this upward stroke of piston A (exhaust) and piston B (compression) together, a fresh double charge of fuel/air mixture will be inducted into the crankcase 11.

At the end of the upward (exhaust) stroke of piston A the exhaust valve 5 in cylinder 1 will close and the inlet valve 4 will open. The engine is now in the position as shown, except that it is piston B that has reached the end of its compression stroke ready for the next power stroke, and piston A that has reached the end of its exhaust stroke ready for the next induction stroke. Each piston will therefore have completed two strokes of a conventional 4-stroke cycle, piston A the power and exhaust strokes, and piston B the induction and compression strokes. The next two strokes (piston B: power and exhaust; piston A: induction and compression) bring the engine back to the postion shown in the drawing, and one operating cycle of the engine will be complete.

The main advantage of this system is that two descending pistons pump a double charge of fuel and air into each of the two cylinders in turn to give increased torque compared with that of a normally aspirated four-stroke engine inducing a single charge into each cylinder. Also, because the double charge of fuel and air is being pumped into each cylinder instead of being sucked in, valve overlap can be considerably reduced to lower exhaust gas emissions.

CLAIMS

1. A four-stroke internal combustion engine comprising one or more pairs of cylinders, a piston mounted for reciprocation in each of said cylinders, a crankshaft, or two separate shafts, rotatably mounted in a crankshaft casing and connected by connecting rods to said pistons, the crankpins on said shaft or shafts being axially aligned whereby the two pistons reciprocate in their respective cylinders in phase one with the other, one or more inlet passageways communicating with the crankcase for admission of a fuel/air mixture thereto, said passageway(s) being provided with a non-return valve, or in a position to be closed by the pistons on their downward stroke, an inlet port and an exhaust port communicating with each of said cylinders, a valve member associated with each of said inlet and exhaust ports and means for opening and closing said valves in timed sequence, and characterised by a transfer passageway or passageways communicating from the crankshaft casing to the inlet ports of said pair of cylinders for feeding thereto a compresed fuel/air mixture from

said crankshaft casing during the downward stroke of the two pistons, the timing mechanism being operative to admit said compressed fuel/air mixture from the crankshaft casing into one of said two cylinders on the first downward stroke of the four-stroke cycle and into the other of said two cylinders on the second downward stroke, and said timing means being operative to open said exhaust valves so as to vent exhaust gases from said one cylinder during the second upward stroke of the said four-stroke cycle and from the said other cylinder during the first upward stroke, whereby each piston operates according to a four-stroke cycle of induction, compression, ignition (power) and exhaustion, but two strokes out of step one with the other.

2. A method of operating a four-stroke internal combustion engine, said engine having one or more pairs of cylinders each having a piston mounted for reciprocation therein and each piston connected to a crankshaft rotatably mounted in a crankshaft casing, each piston in operation performing a four-stroke cycle of induction, compression, ignition (power) and exhaustion, wherein the two pistons of said pair are arranged to reciprocate in phase one with the other, the one performing its induction and compression strokes whilst the other performs its ignition (power) and exhaustion strokes and *vice versa*, and wherein during the compression stroke of the one piston and the exhaustion stroke of the other, an air/fuel mixture is inducted into the crankshaft casing and during the ignition (power) stroke of the one piston and the induction stroke of the other, the said air/fuel mixture is precompressed in said crankshaft casing by said pistons and fed thereby under pressure into the cylinder associated with the piston, which at that time is performing its induction stroke.

3. An internal combustion engine according to claim 1 or method according to claim 2 substantially as hereinbefore described with reference to the accompanying drawing.

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